Introduzione al Modello Standard delle particelle elementari

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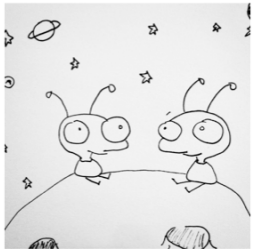
"We're all made of stars"



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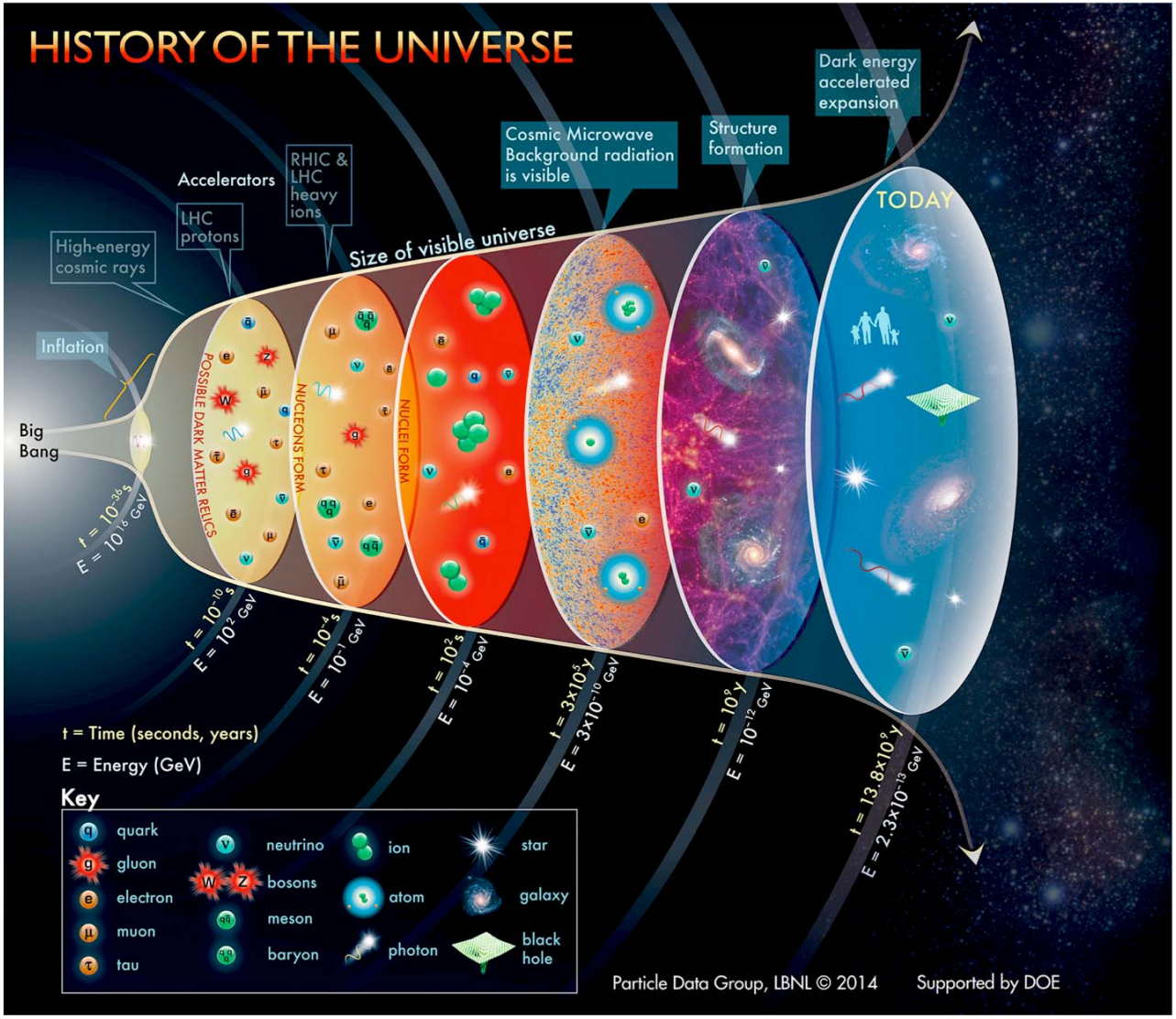
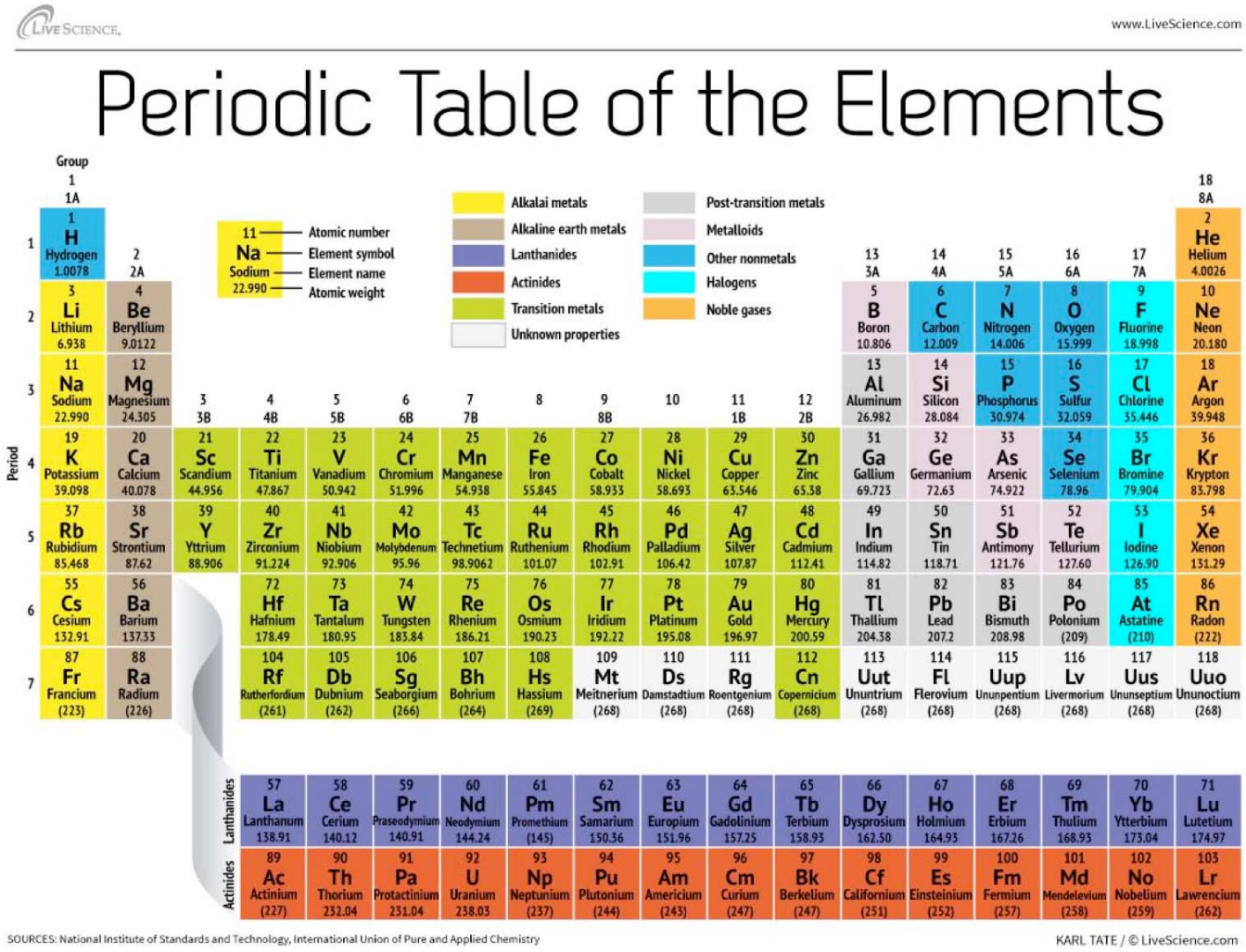
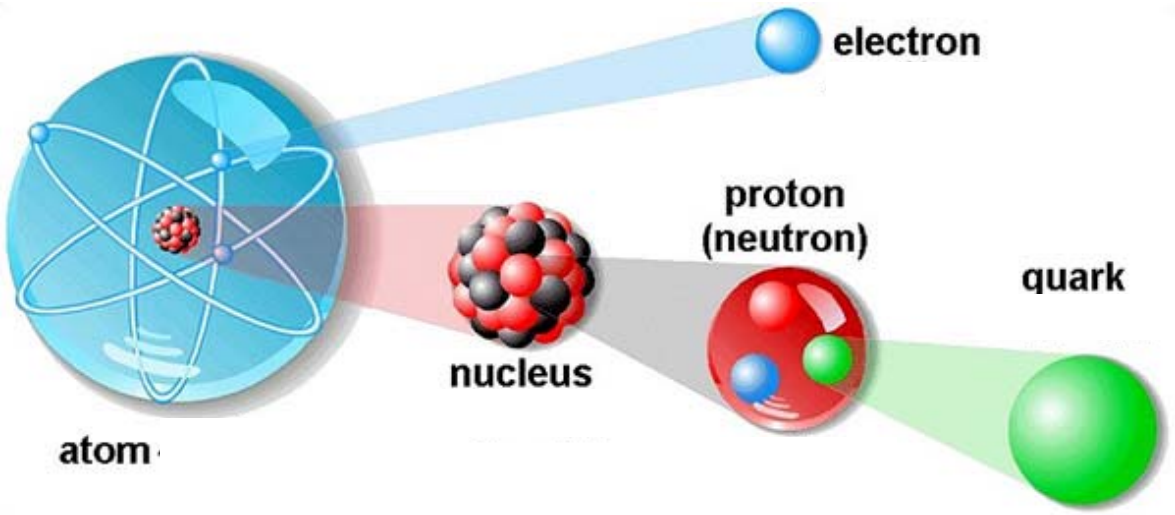
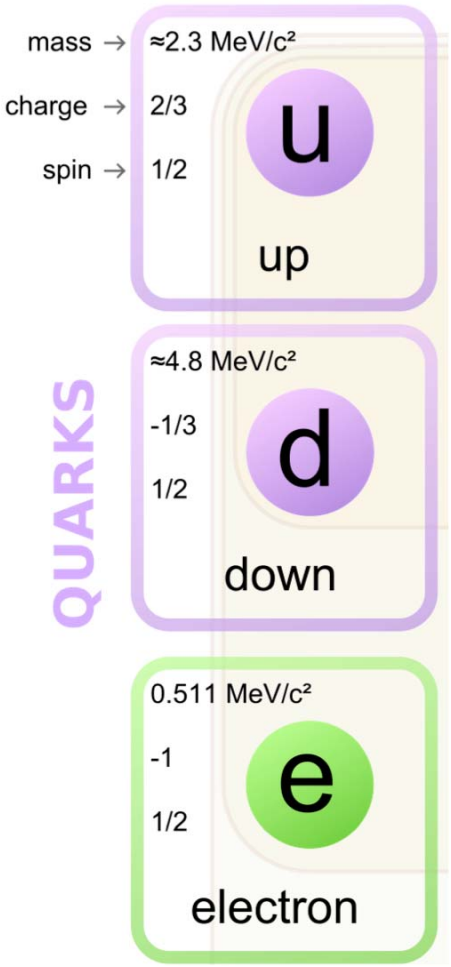


Known elements: from atoms ....



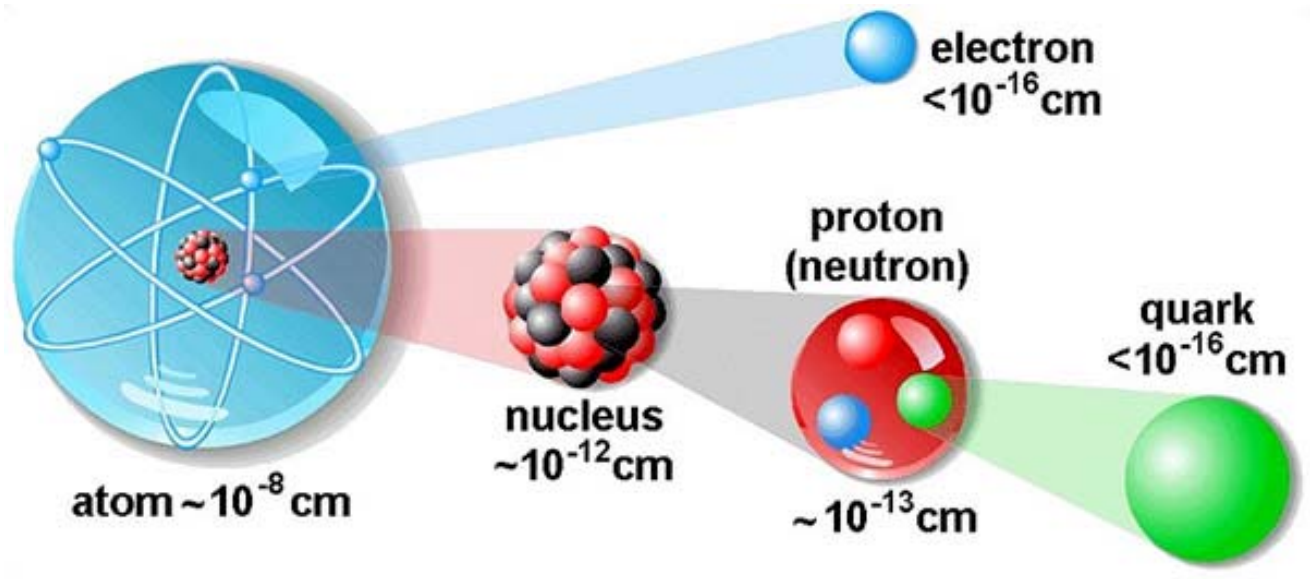
..to their building blocks

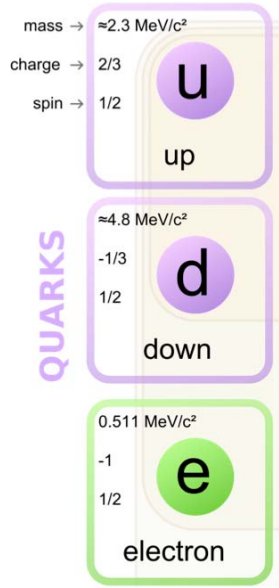




How small (and light) are the smallest?

electron mass:
0.511 MeV/c^2



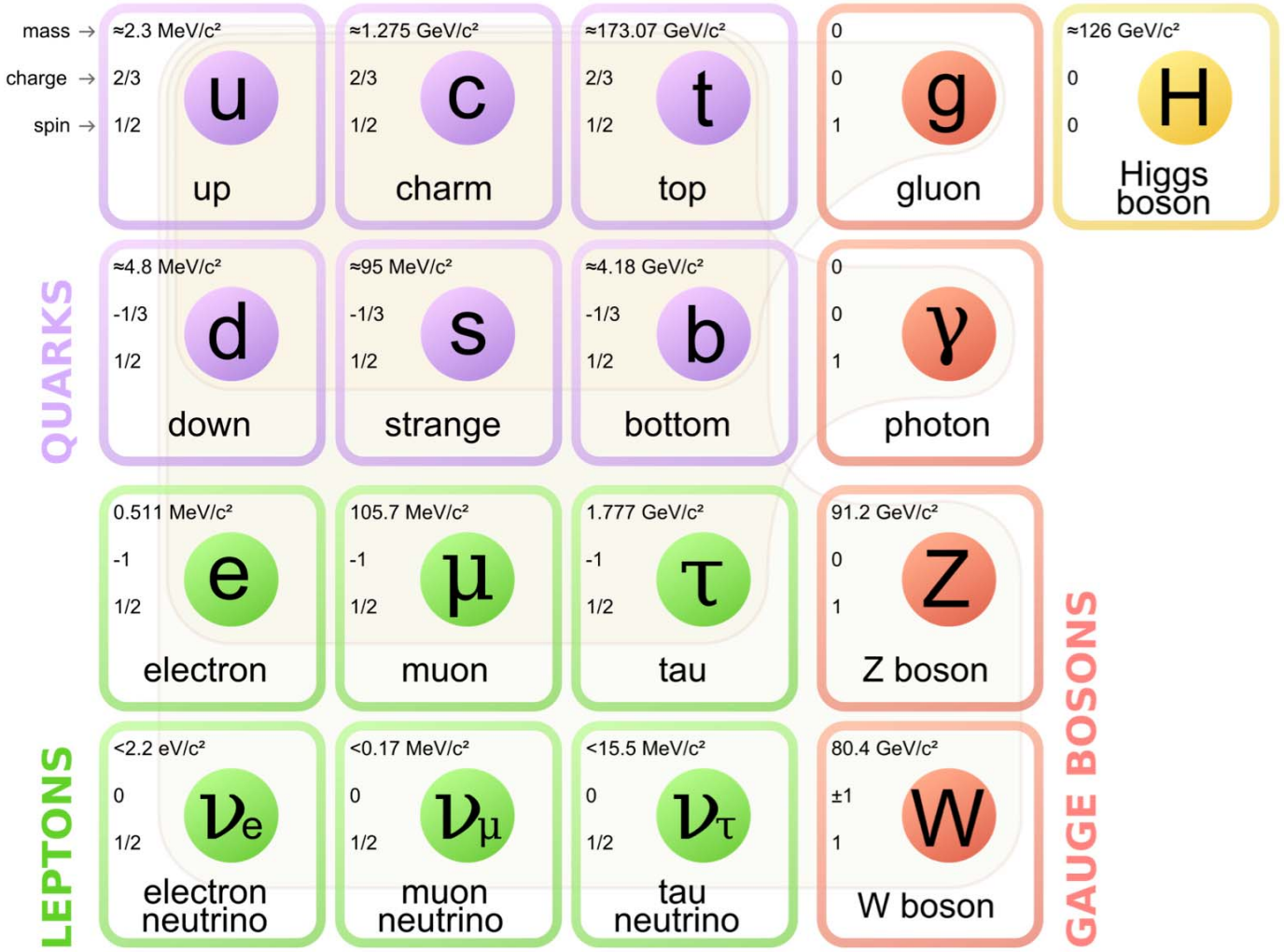


proton mass:
938 MeV/c^2

u-quark mass:
2.3 MeV/c^2

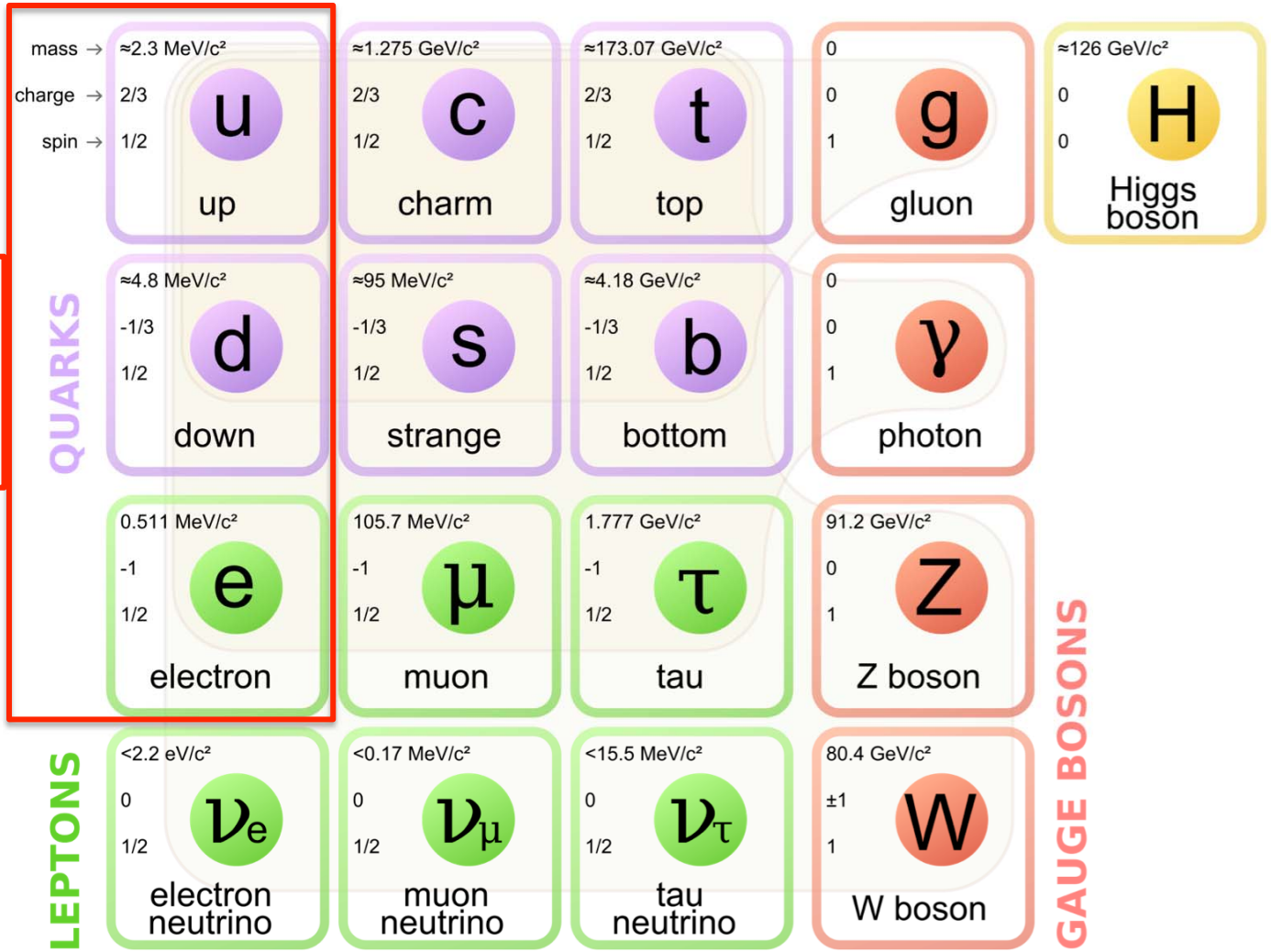
n.b.: 1 MeV/c^2 ~ 2 x 10^{-30} Kg

But there's much more



But there's much more

matters' building blocks



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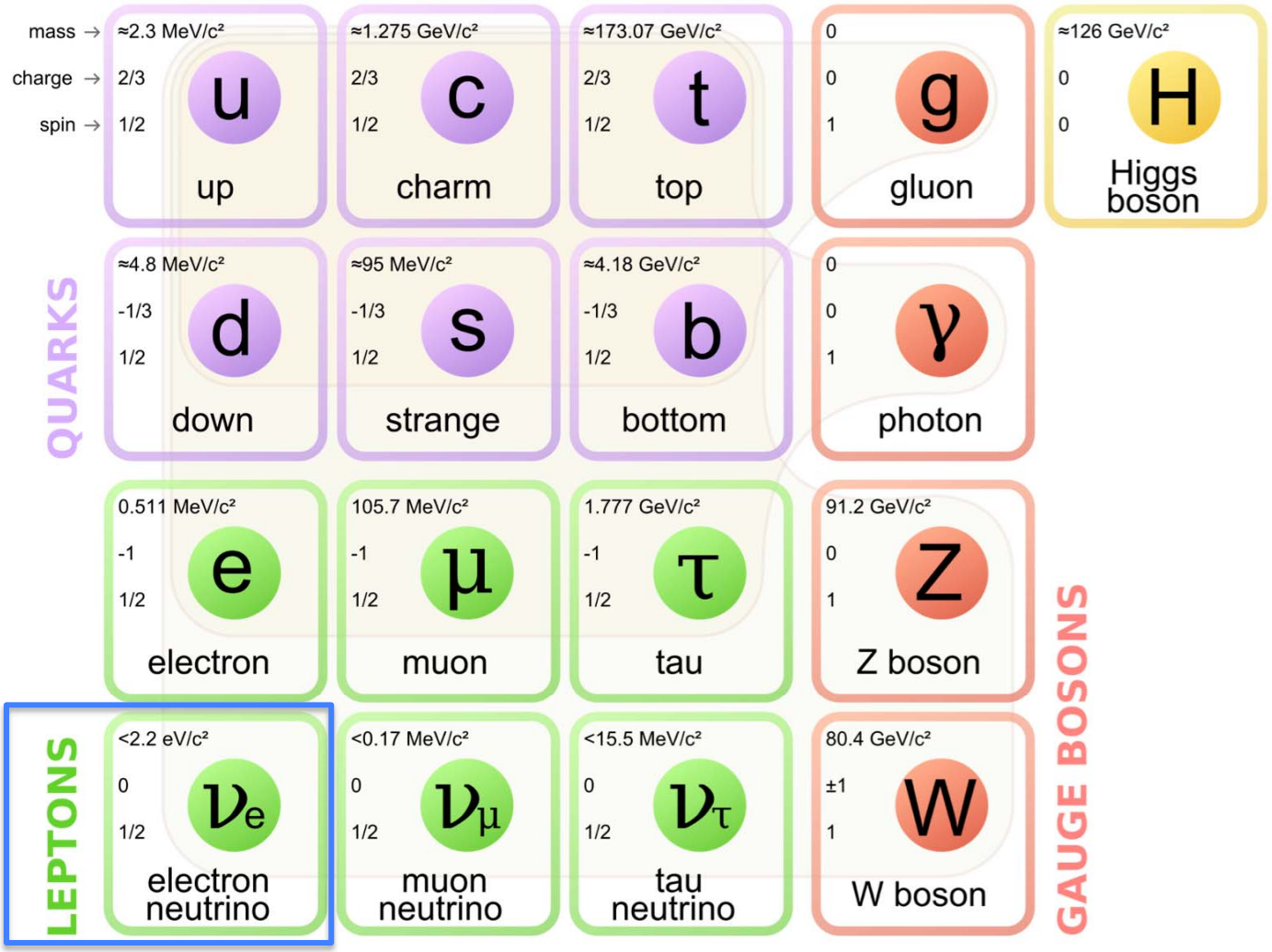
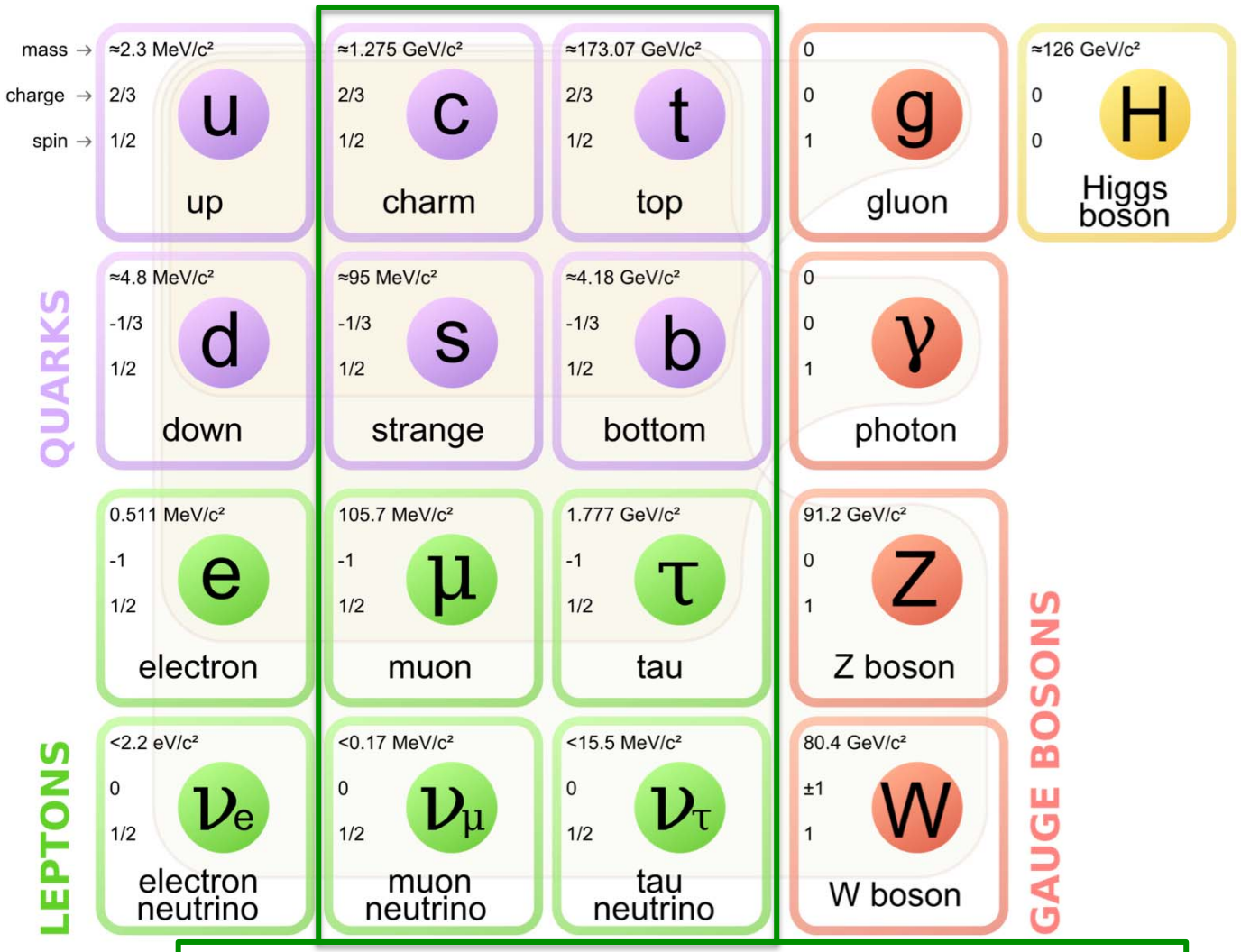


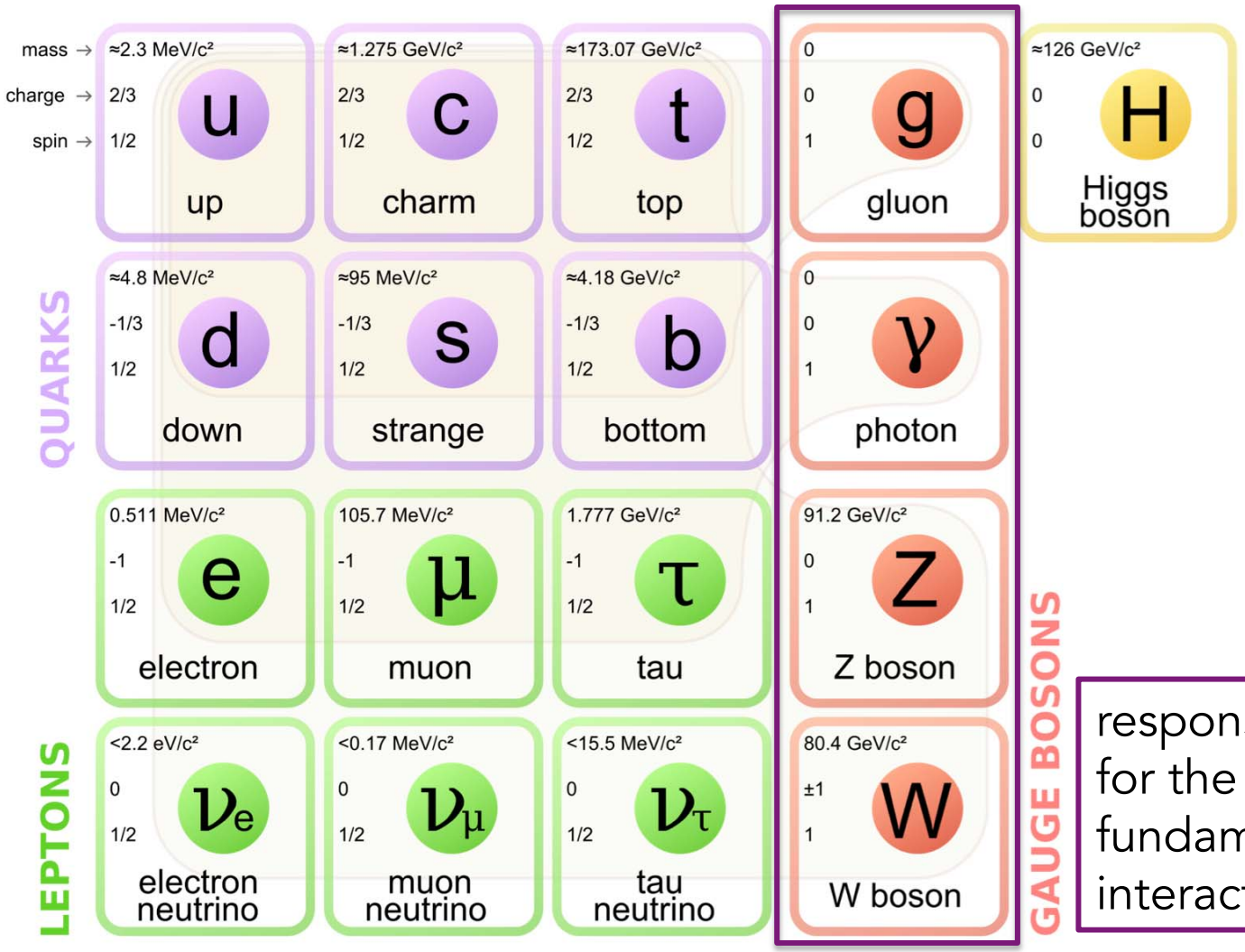
Produced in nuclear β decay

But there's much more



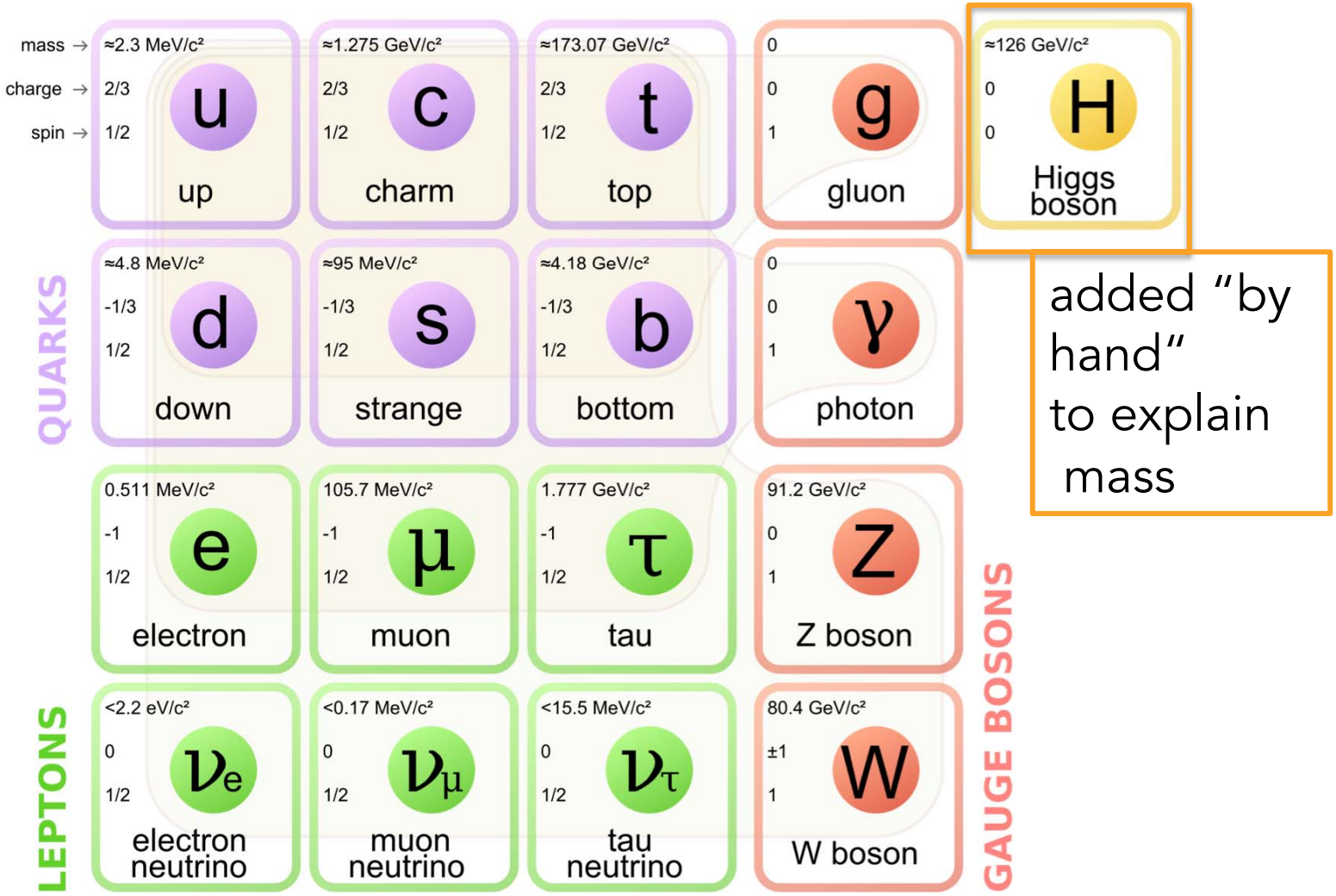
two more copies of matter particles

But there's much more



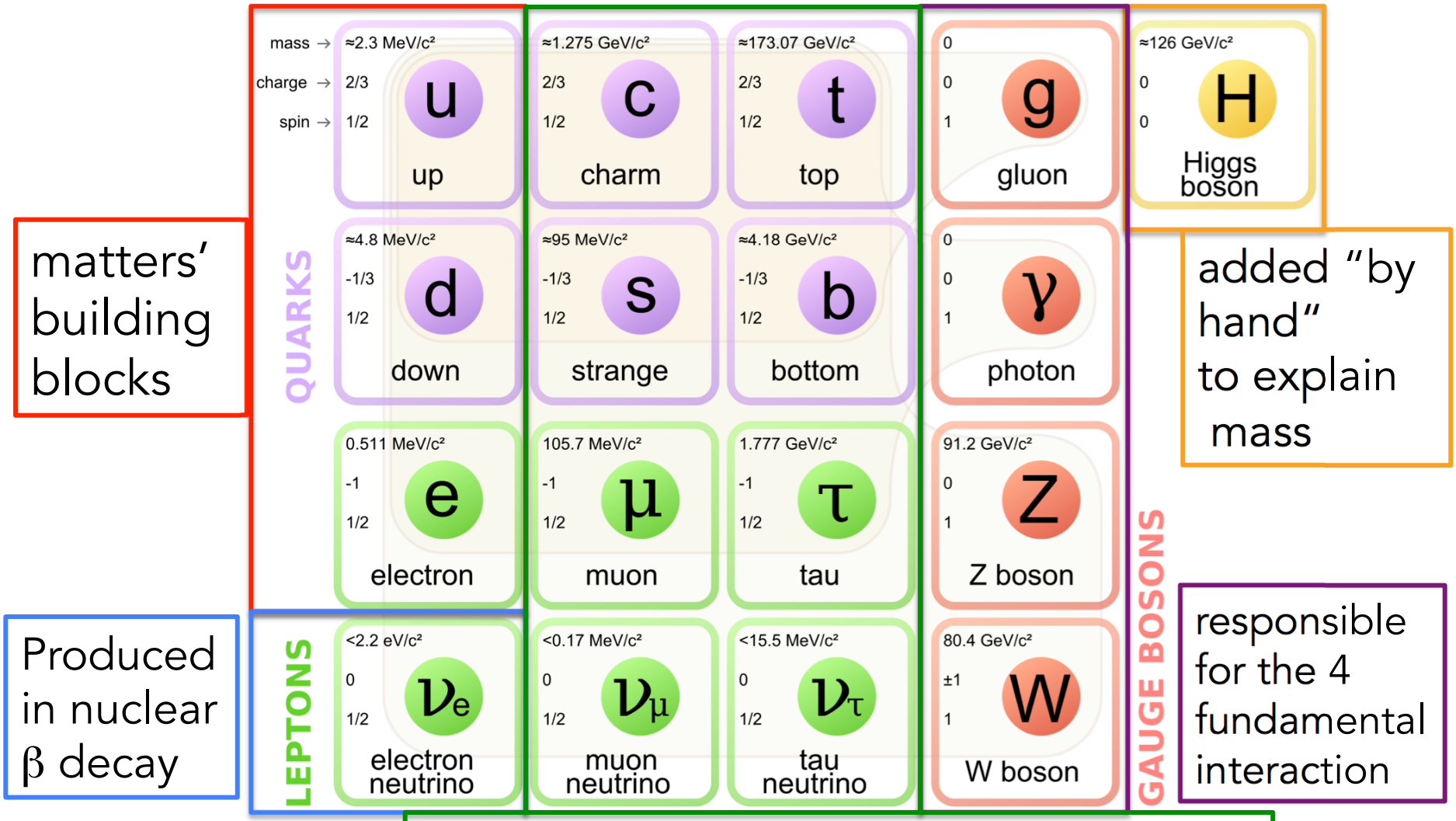
responsible for the 4 fundamental interaction

But there's much more



added "by hand" to explain mass

But there's much more



matters' building blocks

added "by hand" to explain mass

Produced in nuclear β decay

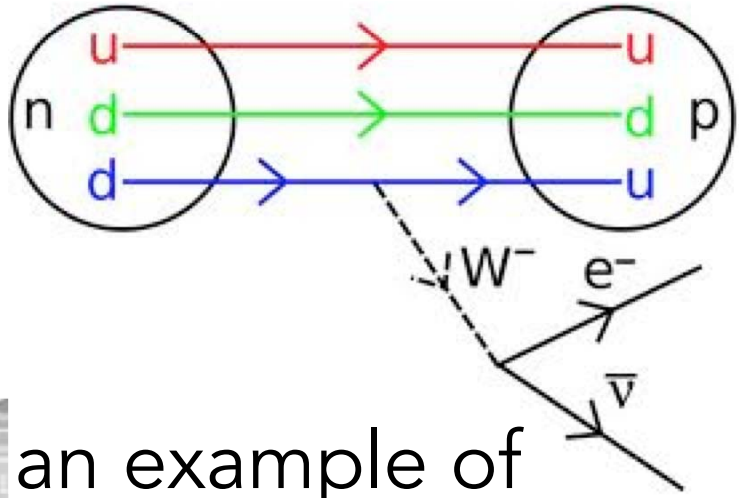
responsible for the 4 fundamental interaction

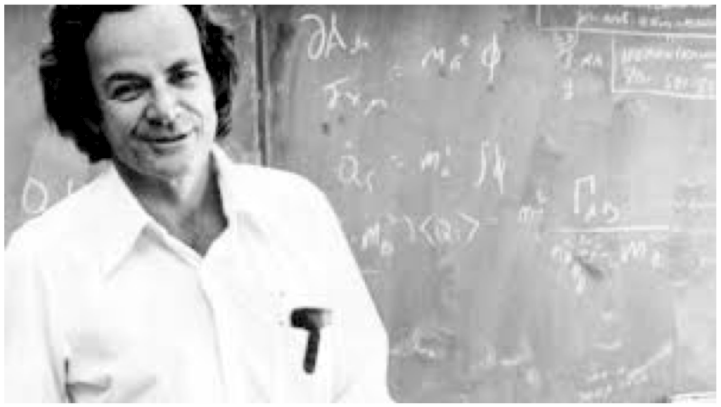
two more copies of matter particles

An example of particle interaction: Nuclear-β decay

- neutron decay to proton + electon + electronic neutrino

$$n \rightarrow p\, e^- \overline{\nu}_e$$





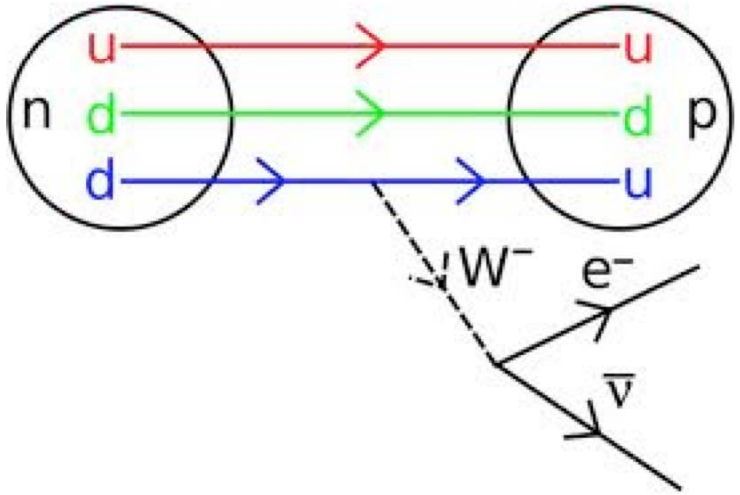
an example of Feynman diagram

An example of particle interaction: Nuclear-β decay

- neutron decay to proton + electon + electronic neutrino

$$n \rightarrow p\, e^{-}\, \overline{\nu}_e$$

- Nature is obedient to CONSERVATION LAWS
  - electric charge
  - leptonic number
  - baryon number
  - energy



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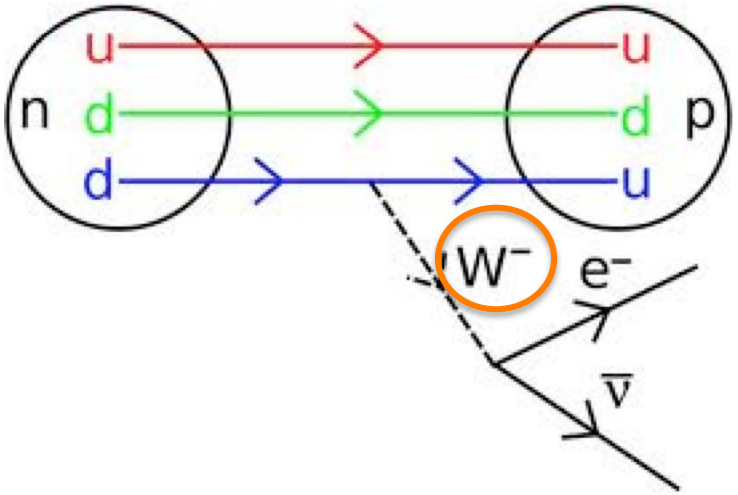


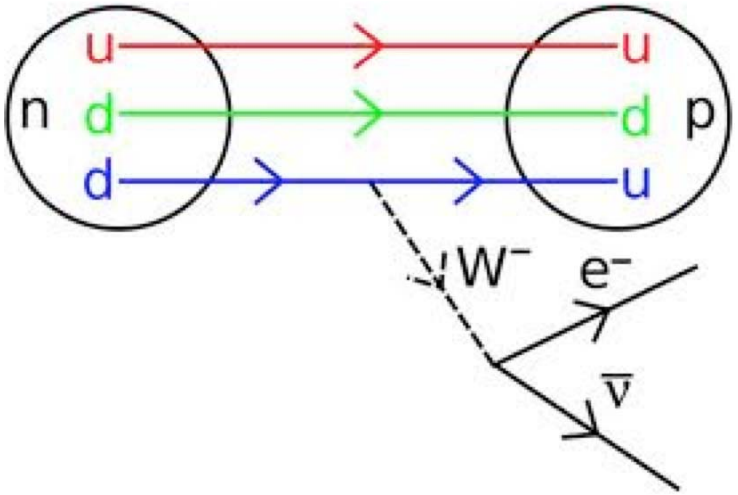
- Decay happens through $W^{\pm}$ bosons exchange, charged weak forces carriers

An example of particle interaction: Nuclear-β decay

- neutron decay to proton + electon + electronic neutrino

$$n \rightarrow p\, e^{-}\, \overline{\nu}_e$$

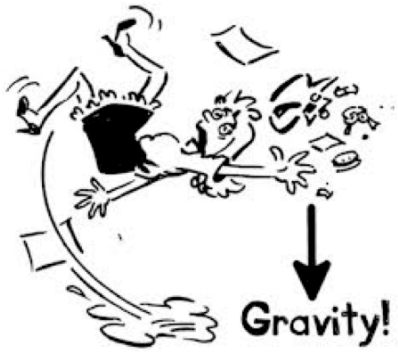
- Quarks are "glued" inside the nucleons by gluons, strong forces carriers
  - an additional quantum numbers related to strong forces: COLOR

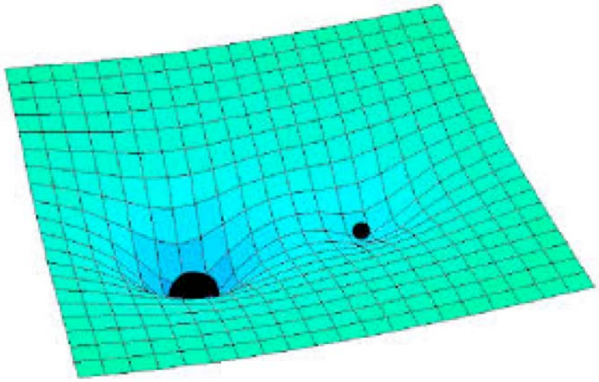


Fundamental interactions

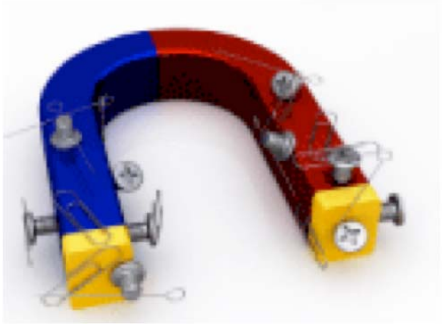
- Other than weak and strong forces, we have 2 more fundamental interaction

GRAVITATIONAL FORCE





ELECTROMAGNETIC FORCE



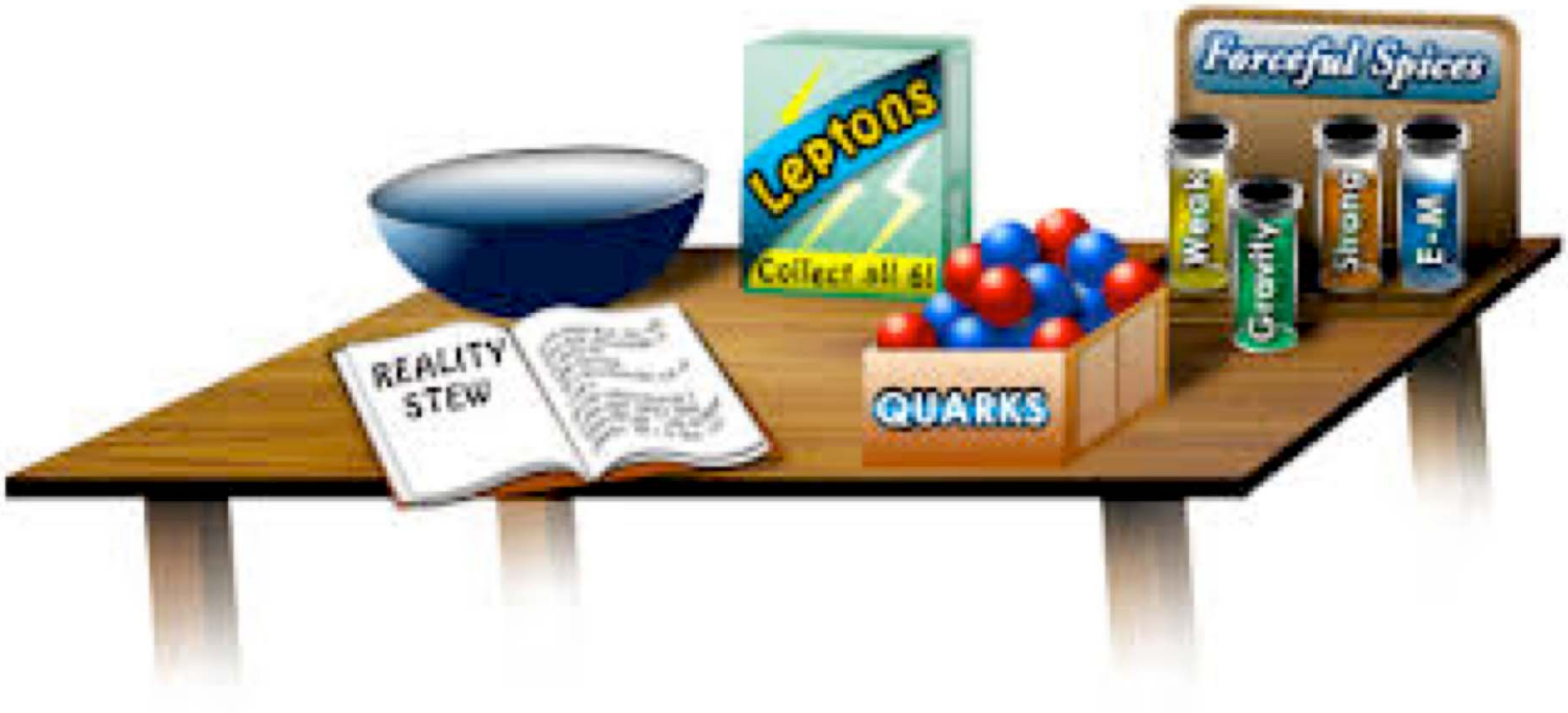
$$\nabla \cdot \mathbf{E} = \frac{\rho}{\varepsilon_0}$$

$$\nabla \cdot \mathbf{B} = 0$$

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$$

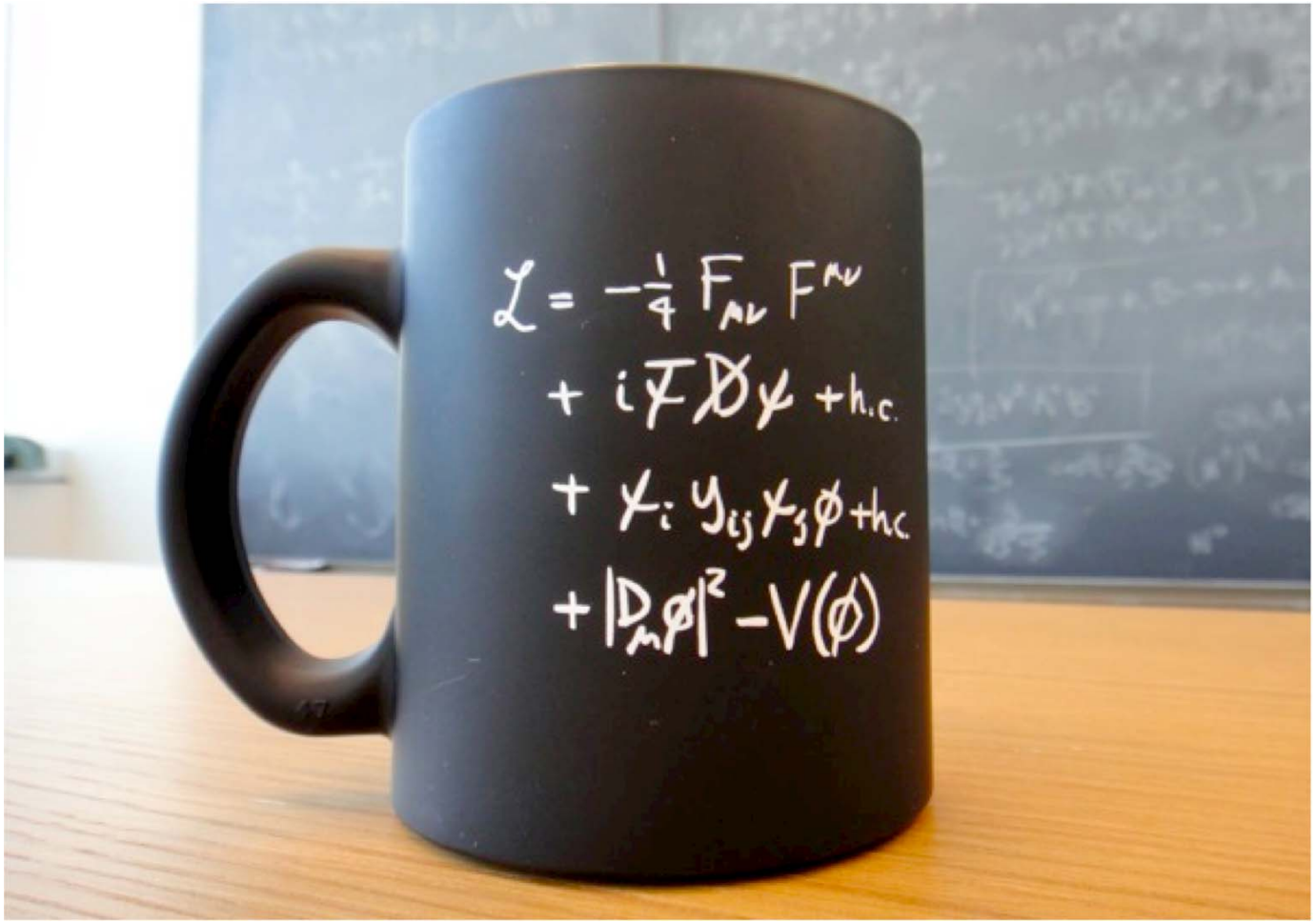
$$\frac{1}{\mu_0}\nabla \times \mathbf{B} = \mathbf{J} + \varepsilon_0 \frac{\partial \mathbf{E}}{\partial t}$$

Particles and Forces: summary

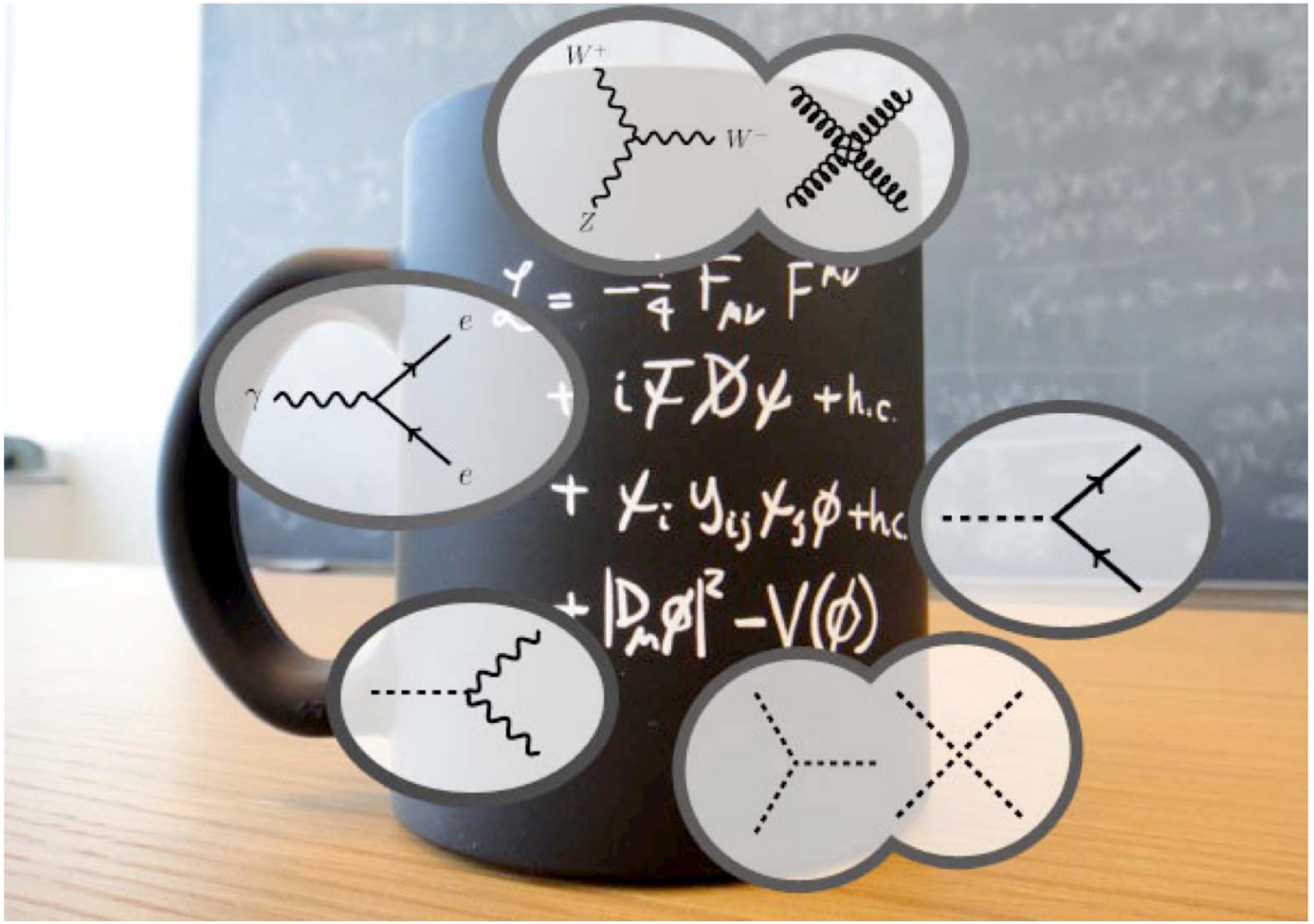


- There's a theory which tries to describe elementary particle properties and they interactions: THE STANDARD MODEL OF PARTICLE PHYSICS

The Standard Model Lagrangian



The Standard Model Lagrangian



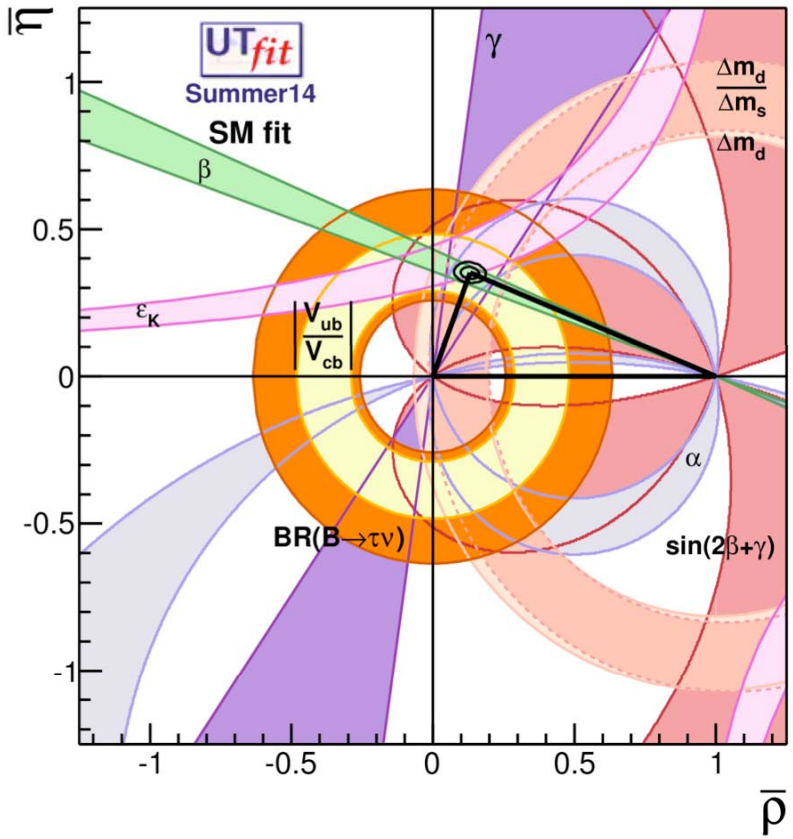
SM it's a working theory!

We have observed a new boson with a mass of

125.3 ± 0.6 GeV

at

4.9 σ significance



...but not the ultimate one!

- Why 3 generations ?
- Why mass/mixing hierarchy?
- What is the origin of CP violation ? (can the SM explain the matter-antimatter asymmetry in the Universe ?)
- Which particle(s) are responsible for dark matter ?
- What about gravity ?
- .....

What's beyond?

- Theorists at work

- Experimentalist at work

THANKS FOR YOUR ATTENTION!